Natural Language Processing | Question-answering | Knowledge Retrieval

Technology Reports

Knowledge Q&A: Direct Answers to Natural Questions

In June, 2012, we began providing the Knowledge Q&A service as an extension to the Shabette-Concier[*1] *voice-agent service, which interprets requests spoken by users in natural language and responds with appropriate actions. Unlike image search or book search, Knowledge Q&A is not limited to a specific field. It takes questions in a wide range of fields, covering a variety of knowledge, and presents direct answers inferred from its internal store of knowledge and the Internet. In this article, we describe details of the Knowledge Q&A service and the system developed to realize it.*

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1. Introduction

In March, 2012, NTT DOCOMO began providing the Shabette-Concier voice-agent service, which interprets requests spoken by users in natural language and responds with appropriate actions. Shabette-Concier has provided responses to the user's natural-language speech, mainly using the results of searches in certain specialized fields, such as transit, weather or image searches, that are provided in the d-menu. However, questions from users are not limited to these specialized areas, and include many from a wide range of fields such as history and general knowledge. For users that are walking or in other typical mobile situations, it is also important to provide answers quickly, without requiring the extra effort of checking through different pages.

As such, we developed a system that interprets the intentions of a question given in natural language, extracts direct-answer candidates from sources such as Web sites on the Internet, and presents them. In June, 2012, we began offering this as the Knowledge Q&A extension to the Shabette-Concier system. This system uses technology from the NTT Cyber space Laboratories [1] (currently the NTT Media Intelligence Laboratories).

With Knowledge Q&A, candidate answer words are presented from a wide range of information, including many that would not apply in the field of a specialized search. This enables users to quickly get answers to questions in a variety of situations. In this article we describe the Knowledge Q&A service and the system that implements it.

2. Overview of Knowledge Q&A Service

The tasks mentioned in Chapter 1 can be divided into two:

- Task (1): Provide answers in a wide range of fields
- Task (2): Answer questions minimizing the work required by users

For Task (1), we prepared a large amount of knowledge data describing question and answer relationships, so that questions can be answered in various fields, as well as a database-type function that interprets user statements

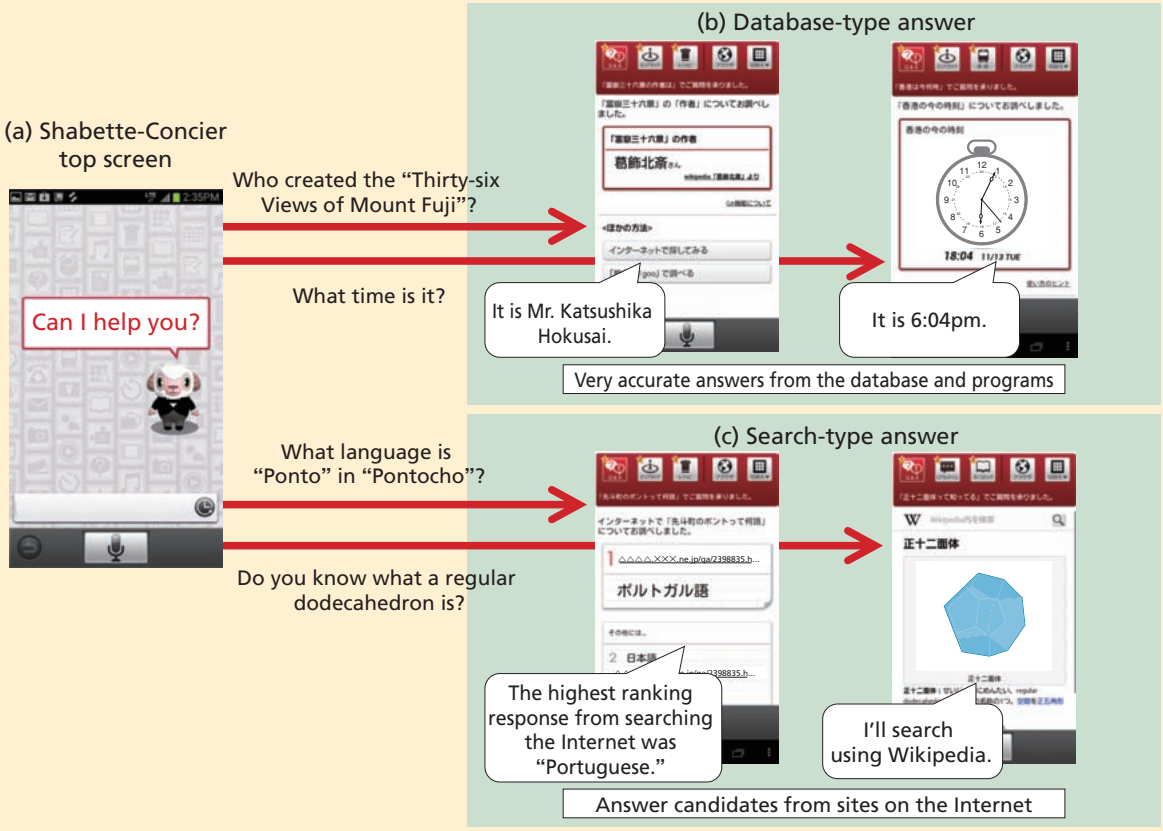
*1 **Shabette-Concier**: A trademark of NTT DOCOMO Inc.

appropriately and presents an answer. This enables the system to provide accurate answers to a wide range of questions in various formats. By using an extendable data description format, we can continually expand the knowledge data and broaden the range of accurate answers available.

However, the range of questions that can be handled with this database-type function is still limited, so we also prepared a search-type function, which infers an answer from candidates found in information on the Internet. The search-type function uses the ever-expanding information on the Internet in the form of Web sites, tweets and others. This allows answers to be presented for an extremely wide range of fields, also covers infrequent questions.

For Task (2), through careful interpretation of the natural-language question from either the database-type or search-type function, we enabled the system to provide a direct answer to the user's query rather than simply displaying the content or web page containing the answer. For the keywords "Thirty-six Views of Mount Fuji" and "Creator," an ordinary search engine would list Web pages containing these keywords and users would need to select the answer they desire from among those displayed. Rather than this, the data-base type function answers with stored knowledge of who created "Thirty-six Views of Mount Fuji," and the search-type function temporarily stores the pages received from the search engine and statistically processes them to infer the answer, so that a direct answer can be given.

An illustration of using the Knowledge Q&A function is shown in **Figure 1**. When it is asked a question regard-



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※This is provided only in Japanese at present.

Figure 1 Using Knowledge Q&A

ing general knowledge, such as "Who created the Thirty-six Views of Mount Fuji?" on the top screen of Shabette-Concier (fig. 1(a)), it replies with what is thought to be the answer. If the user's question can be answered with the database-type function, the answer is presented and read out loud (fig. 1(b)). Answers to other questions are inferred using the search-type function, and also displayed and read-out (fig. 1(c)). In this way, questions that are asked frequently and for which answers can be prepared ahead of time can be answered very accurately by the database-type function, while answers to less-frequent, more-diverse questions can be inferred by the search-type function. This greatly expands the overall range of scenarios in which users' questions can be answered. In both cases, questions can be asked using natural language, a feature of Shabette-Concier, and (candidate) answers are presented and read out. This greatly reduces additional effort required of the user.

3. Knowledge Q&A System

3.1 Overview

The structure and operational flow of the Knowledge Q&A system are shown in **Figure 2**. It is composed of the database-type Q&A server, the search-type Q&A server, and the front-end server. The database-type and search-type servers generate (candidate) responses of their respective types, and the front-end server controls the other two servers and handles the user interface.

The front-end server receives the user's natural-language question from the Shabette-Concier application, as text after speech recognition (fig. 2(1)), and sends a query to the database-type Q&A server (fig. 2(2)). If the database-type Q&A server returns an answer, the front-end server formats it and sends it to the Shabette-Concier application. If the database-type Q&A server cannot

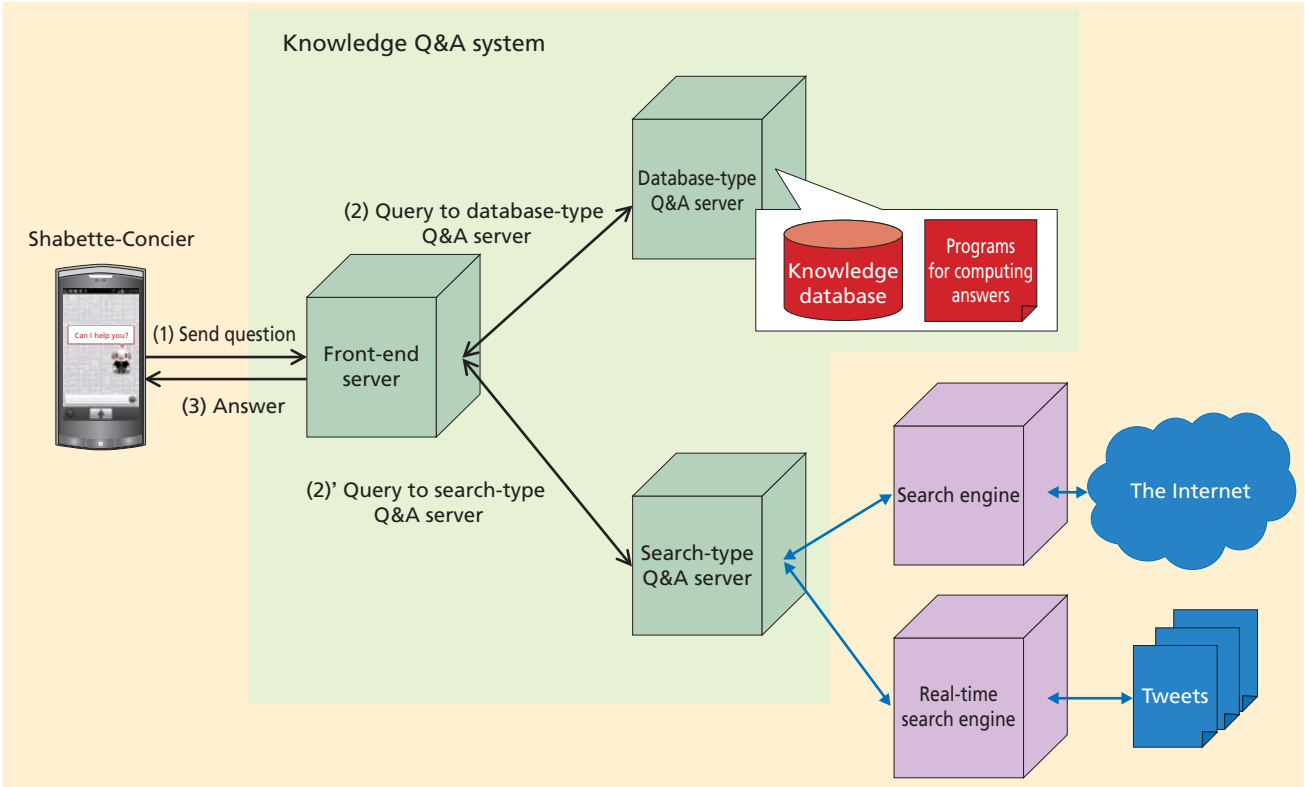

Figure 2 Knowledge Q&A system structure and operational flow

return an answer, the front-end server sends a query to the search-type Q&A server (fig. 2(2)'), and similarly sends any response to the Shabette-Concier application (fig. 2(3)). To answer questions, the database-type Q&A server has a knowledge database and also programs that are able to compute answers. The search-type Q&A server is connected to an external search engine and a real-time search engine, and it infers an answer to the user's question from the search results of each. The external search engine is a service that returns results from crawling over various types of sites on the Internet, while the real-time search engine searches through real-time tweets for results[2].

3.2 Database-type Q&A Server

The database-type Q&A server answers questions that can be answered accurately in ways that can be prepared ahead of time. We will now describe three approaches used by the database-type server to answer questions, called rule, entity-property and program.

1) Rule Approach

To provide accurate answers to questions that occur frequently, the rule approach stores question patterns and corresponding answers in a knowledge database. When a question that conforms to one of the question patterns is received, the corresponding answer is output.

2) Entity-property Approach

The entity-property approach analyzes the question using machine learning[*2] methods to extract an entity and a property, which it then uses as conditions in searching the knowledge database for an answer. The entity is the object of the response, and the property is a quality or characteristic of that entity. Answers for a large number of entities and properties are stored in the knowledge database ahead of time. Examples of current entity-property knowledge data are given in **Table 1**.

The information prepared in the knowledge database focuses mainly on basic knowledge including statistical data, historic events and culture.

Both entities and properties are made so that it is easy to add to them. For example, properties that are not often needed and only exist for certain entities, such as the favorite sayings of a particular person, can be added for only some people. This allows for expansion in the range of questions that can be answered flexibly and quickly.

Entity-property processing is shown in **Figure 3**. The entity part of the input question is first detected using a process called sequence labeling[*3]. In fig. 3, "Thirty-six Views of Mount Fuji" is selected from the question, "Who created Thirty-six Views of Mount Fuji?"

Then, from the overall predisposition of the question, the system decides which of the properties in the knowledge database the question is regarding. A technique called a multi-class classification[*4] is used to accomplish this. Deciding based on the overall predisposition of the question allows the system to respond to various ways of asking a question. In the example in fig. 3, the system detected that the property being requested was "Creator."

Finally, the knowledge database is searched using the entity and property detected, and if at least on answer is found, it is output. In the example in fig. 3, the database was searched for the "Creator" of "Thirty-six Views of Mount Fuji," and the answer "Katsushika Hokusai" was output.

3) Program Approach

The program approach extracts the necessary values from the question text, uses them in some sort of processing to

Table 1 Examples of knowledge data prepared in entity-property form

Data field	Entity examples	Property examples
People	Famous people, cultural figures	Birth date, birthplace, blood type, weight, real name, produced work
Arts/culture	Movies, books, music	Author, publisher, artist
Medicine	Illnesses	Symptoms, causes, treatments
City/town/village statistics	Cities, towns, villages	Population, area
Business	Corporations	Name of representative, number of employees
History	Events	Year of occurrence
Geography	Rivers, mountains, cities	Location, watershed, source

*2 **Machine learning**: A mechanism allowing a computer to learn the relationship between inputs and outputs, through statistical processing of example data.

*3 **Sequence labeling**: A method for automatically applying appropriate labels to members of sequences such as character strings, based on a decision criteria obtained through statistical processing of examples.

*4 **Multi-class classification**: A method for classifying input data into multiple groups based on a decision criteria obtained through statistical processing of examples.

obtain an answer and outputs the answer. Examples of the types of questions supported by the program approach are shown in **Table 2**. Currently, this approach is used to answer questions concerning times and dates, answers that change with the passing of time, and questions that require computation and for which there is no answer already in the database.

Questions such as unit conversions, simple calculations and the time are very common in the daily lives of users, so this approach can answer questions that are very helpful.

3.3 Search-type Q&A Server

The search-type Q&A server answers questions differently, depending on the type of question. Examples of the types of questions that the search-type Q&A server can answer are shown in **Table 3**. For each of them information found on the Internet is processed statistically to generate an answer to the question, but how the answer is generated differs. In this article, we will describe how questions of one of these types, the factoid, are answered.

Factoid-type questions are those that can be answered using short answers such as people's names, geographic names, organization names, prices, dates, times or distances[3].

The procedure for answering factoid-type questions is shown in **Figure 4**. First, a decision is made whether the subject of the question is one of over 100 extended named entity types[4] such as people's names, place names, organization names, dates or quantities. In the example in fig. 4, 'National Language name' is selected for the question, "What language is the 'Pont' in 'Pontochou'?"

Next, the system decides whether to obtain the answer using the search engine or the real-time search engine, based on the question text. The real-time search engine is used for questions for which timeliness is important, and

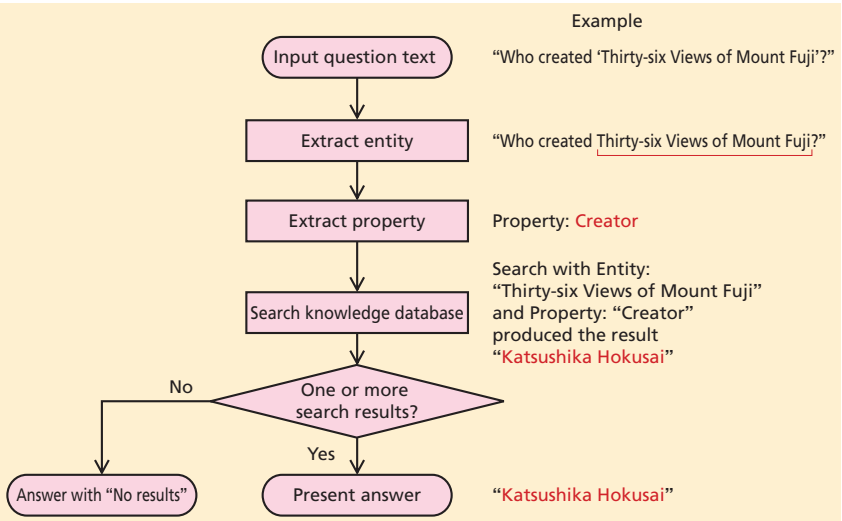

Figure 3 Entity-property processing

Table 2 Examples of patterns supported by program-type responses

Pattern	Actions	Example
Calendar	Reply with date or day-of-week	What is the date on Thursday next week? What day of the week is it today?
World clock	Reply with time in various cities and countries	What time is it now in New York?
Year conversions	Reply with year number, age conversions, etc.	What year is Showa 53 on the western calendar? What grade are seven-year-olds in?
Unit conversions	Reply converting units for weight, length, etc.	How much is 60 miles in kilometers?
Calculator	Perform arithmetic operations and reply with result	How much is 40% off of 20,000 yen?

Table 3 Examples of types of questions supported by the search Q&A server

Type	Action	Example answers
Factoid	Answers facts about people, dates, etc.	What language is the "Pont" in "Pontochou"? (area of Kyoto)
Definition	Answers with Wikipedia pages for requests for definitions.	Do you know what a regular dodecahedron is?
Association	Answer with references to the Internet for questions about associations.	What kinds of confections come from Kyoto?

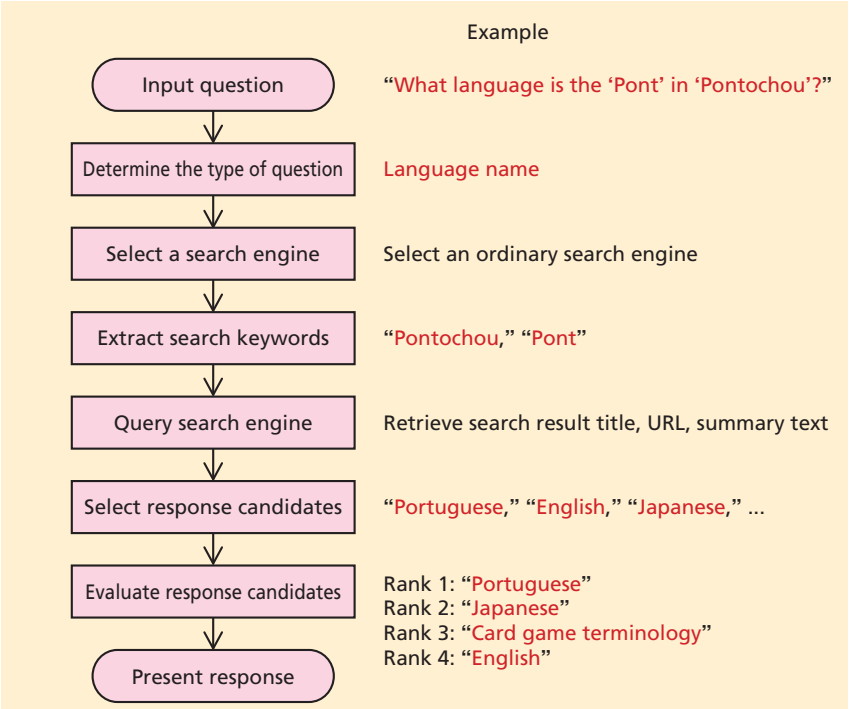

Figure 4 Process for answering factoid questions

the ordinary search engine is used for other questions. In the example in fig. 4, the question is a general fact, so the ordinary search engine is selected.

Then, keywords are extracted for use in the search engine query. This is done by performing morphological analysis[*5] and selecting the applicable parts of speech from the results. In the example in fig. 4, the two keywords, "Pontochou" and "Pont" were selected.

The pages containing the above keywords returned by the search engine are searched, selecting words to be used as candidate answers. In the example in fig. 4, several words were selected from the search result summaries, including "Portuguese" and "Japanese."

The answer candidates are then evaluated for suitability (reliability) as answers to the question. To evaluate candidates, various information (feature values) such as the number of times the response appears in the search results, how close the candidate appears to the search terms in the search result, and the desired answer type ("National Language name," "Language Other," etc.) is extracted and a machine-learning mechanism is used to compute the reliability of the candidate.

Finally, the answer candidates are output in order of reliability.

4. Conclusion

In this article, we have described the Knowledge Q&A service, which is an extension to Shabette-Concier, together with its system structure and operation. The system is able to present direct answer candidates for a wide range of questions using a combination of two functions: a database-type function, which returns reliable answers to questions using question-answer relationships that can be prepared beforehand; and a search-type function, which returns answers inferred from the extremely wide range of knowledge on the Internet.

In the future, we will extend the functionality and add to the data in practical ways, incorporating trends in usage and user opinion, so that it can support users in a variety of life scenarios.

References

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[4] Sekine's Extended Named Entity Hierarchy. http://nlp.cs.nyu.edu/ene/

*5 **Morphological analysis**: The process of dividing a sentence into a sequence of morphemes, which are the smallest units of meaning.